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Forecasting Beef Cattle And Hog Prices by Quarter-Years

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SUMMARY

The sharp fluctuations in beef cattle and hog prices that have occurred since the end of World War II were partly the result of changes in the quantities of livestock produced. Other factors were present which also affected the level and pattern of livestock and meat prices. Disposable personal income per capita increased about 20 percent in real dollars during the 10-year period, 1947-56. A gradual shift in demand from pork to beef persisted throughout this period. Marketing costs increased sharply. Finally, the market structure was in the process of change and adaptation to the increasing demands for "built-in" maid services and other marketing innovations. These changing economic factors affect the accuracy of livestock price forecasts.

In this study, alternative methods of forecasting changes in beef and pork prices were derived from quarterly data covering the 32-quarter period, 1949 through 1956. The alternative forecasting equations were used to obtain several sets of predicted prices for each of the three major market levels—primary, wholesale and retail. Comparisons of the reported and predicted prices provided a test of predictive accuracy.

Two different models of market relationships were used in the study. First, the dressed, or wholesale, meat market was considered as the critical pricing level where prices adjusted to predetermined levels of beef and pork quantities and to consumer incomes and tastes. One set of estimates of the wholesale price-quantity relationships showed that a + 1 pound change in the per capita wholesale quantity of beef—where wholesale quantity was equivalent to commercial quantity less the net change in cold storage holdings during the quarter—was associated with a –3.9 cent change in wholesale beef price and a –1.4 cent change in wholesale pork price. (All prices were adjusted by the Consumers' Price Index to constant 1947-49 dollars.) A + 1 pound change in the per capita wholesale quantity of pork was associated with a –4.3 cent change in wholesale pork price and a –1.1 cent change in wholesale beef price. Estimates of the income effects on wholesale price based on survey data were used in the forecasting equations (0.050 and 0.133, respectively, for beef and pork). The computed income effect on pork price probably overestimated the actual income effect, hence the inverse pork price-quantity relationships probably were underestimated. Exclusion of the income effect as an explanatory variable in the pork price equation resulted in larger estimates of the inverse effects of changes in wholesale quantities. A + 1 pound change in per capita wholesale pork and beef quantities was associated with a –4.6 cent and a –1.8 cent change, respectively, in the wholesale pork price. In comparison, the beef price-quantity estimates differed only slightly.

The alternative model of market relationships involved the national retail market as the critical pricing level. The wholesale and primary markets presumably adjusted to the quarterly changes in retail prices, given the retailing and wholesaling margins. Retail prices were established with reference to the consumer demand structure and the average quarterly levels of beef, pork and poultry prices, and consumer income and tastes. A +1 pound change in per capita beef consumption was associated with a –4.0 cent change in retail beef price and a –1.4 cent change in retail pork price. A +1 pound change in per capita pork consumption was associated with a –5.6 cent change in retail pork price and a –1.6 cent change in retail beef price.

Price reaction coefficients were derived with reference to the wholesale market level. First, however, the average quarterly wholesale prices were estimated using one of the wholesale price equations. Retail and live prices then were related to both the reported and the estimated wholesale price. The findings show that a 1 cent change in the reported wholesale beef price was associated with a 1 cent change in the average retail beef price and a 0.7 cent change in the average beef cattle price. A 1 cent change in the reported wholesale pork price, however, was associated with a 0.9 cent change in the average retail pork price and a 0.6 cent change in the average hog price. The retail and wholesale prices were on a carcass weight basis, while the live prices were on a liveweight basis. The price reaction coefficients differed slightly using estimated wholesale prices. In addition, each of the price equations included a fixed component. Finally, the wholesale-retail price relationships were inverted when used in estimating wholesale prices from the estimated retail prices (according to the alternative model of market performance).

The price reaction equations were transformed into margin equations to estimate the live, wholesale or retail prices, given the estimates of the wholesale or the retail prices. The retailing beef margin, on a carcass weight basis, included a fixed component of 10.7 cents and a variable component based on the wholesale price. A +10 cent change in the estimated wholesale beef price was associated with a +0.3 cent change in the beef price markup per pound carcass weight. The retail pork markup included a fixed component of 13 cents and a variable component showing a +10 cent change in the estimated wholesale pork price associated with a –2.2 cent change in the retail markup. Thus, the fixed component, in constant 1947-49 dollars, comprised the major part of the total retail markup on beef and pork prices.

The two wholesaling margins also included both fixed and variable components. The wholesale margin per pound liveweight of beef cattle and hogs included fixed components of 3.3 cents and 3.5 cents, respectively. In addition, a +10 cent change in the beef cattle price was associated with a –1.1 cent change in the wholesale beef margin on a liveweight basis. A +10 cent change in the average hog price was associated with a –2.2 cent change in the estimated wholesale pork margin. The wholesale beef and pork margins on a liveweight basis were 59 percent and 47.37 percent, respectively, of the values on a carcass weight basis. Moreover, the magnitude of the wholesaling margin depended on the level of the live price. The latter was affected by changes in the rates of marketing beef cattle and hogs and in the levels of beef and pork cold storage holdings.

The price relationships for beef and pork were computed to show the vertical demand elasticities—the percentage change in quantity associated with a +1 percent change in price—at each of the three market levels.

The computed price elasticity coefficients for beef and pork, respectively, were –0.7 and –0.6 at the wholesale level; these were compared with the estimated own-price elasticities of –0.8 and –0.6 at the consumer level and –0.6 and –0.4 at the primary market level.

Annual trend and quarterly, or seasonal, effects also were estimated for each market level. The annual trend effects were confounded with the income effects—a positive income effect with respect to beef and pork prices.

Finally, sets of three beef and three pork prediction equations were used to forecast prices at each of the three levels in the marketing system. The initial set of beef cattle and beef price equations for live, wholesale and retail market levels yielded forecasts for selected quarters in 1957 with standard errors of 2.8 cents, or less, where the forecast prices were in cents per pound, in 1947-49 money equivalents, and the quantities were in pounds per capita. The initial set of hog and pork price equations yielded forecasts for the same quarters in 1957 with standard errors of 2.2 cents, or less. The forecasts of retail prices, given the wholesale prices, were more precise, but their precision depended on the precision of the wholesale price forecasts. Live prices also were forecast more precisely than wholesale prices. The largest standard errors of forecast were obtained at the wholesale market level, which, however, involved higher values per pound than at the primary market level. Each of the price forecasts was improved with the more complete forecasting equations.

All price forecasts were dependent upon precise forecasts of per capita commercial production and the net quarter-to-quarter change in cold storage holdings of beef and pork. Given the expected changes in beef and pork quantities, wholesale prices of beef and pork were forecast with standard errors of 4 to 5 percent of the average 1949-56 wholesale beef and pork prices.

Forecasting Beef Cattle and Hog Prices by Quarter-Years[1]

BY WILBUR R. MAKI

Forecasts of changes in the market demand for livestock and meat are important to livestock producers and livestock marketing agencies. The retail prices at which given supplies of meat will move from the retailer to the consumer depend not only upon the quantity and form of these supplies, but also upon the prices of other goods and services, the disposable income of consumers and the pattern of consumer tastes. The prices paid for livestock at the primary markets are related to wholesale meat prices and, ultimately, to retail prices. Thus, forecasts of livestock prices at the primary market, or farm level, depend upon forecasts of the consumer demand for meat and of the price spreads between different market levels.

OBJECTIVES

The primary objective of this study was to estimate demand and price relationships for beef and pork as a basis for forecasting short-term, or quarterly, changes in beef cattle and hog prices. The ability to forecast changes in beef cattle and hog prices provided a test for the model of market performance used in this study.

Quarterly data were used to estimate demand and price relationships for the 32-quarter period, 1949-56. Moreover, the quarterly estimates of the market relationships were used with more recent estimates of quarterly prices and quarterly rates of production and consumption to forecast short-term changes in beef and pork prices. Specifically, the statistical method of least squares was used to estimate three sets of market relationships—the wholesale, the retail and the primary market levels.

ANALYTICAL APPROACH

The marketing system was conceived as a mechanism to adjust prices to changes in the quantity of production and the quantity of consumption. Obviously, the quantity of beef and pork consumed was equal to the quantity produced, less net exports and net changes in inventories. Therefore, the quantity consumed could be expressed as a function of quantity produced. This study, however, was addressed to the problem of estimating the market demand and, ultimately, the prices for beef cattle and hogs. Therefore, the first step in this study was the specification of a set of market relationships to describe short-term price behavior in the marketing of beef cattle and hogs.

MARKET RELATIONSHIPS

The behavior of beef and pork prices at different levels in the marketing system may be related to changes in the production of beef cattle and hogs (6, p. 107-118). The rate of production, or commercial slaughter, of beef cattle and hogs depends on the livestock numbers on farms, weight-age composition of these numbers, stocks of grain, pasture conditions, relative prices of feed and livestock and other factors (2, 4, 6). Given the estimates of quarterly commercial slaughter, however, the end-of-quarter inventories of beef and pork in cold storage could be estimated.

The inventory prediction equation was the first in the series of equations used to forecast prices at different market levels on the basis of the 1949-56 market price relationships. Once inventory levels were established for the quarterly time periods, wholesale production was presumed identical to commercial production, less the net change in inventory levels.

Next, the wholesale price relationships were estimated, and the equations were used to predict quarterly wholesale prices, given the wholesale quantities of beef and pork, consumer income and tastes. The wholesale price relationships were derived in terms of both reported and estimated prices and quantities. Underlying the estimation procedures was the assumption that a series of unilateral relationships existed between the wholesale prices and the wholesale quantities; i.e., during any 3-month period, changes in wholesale quantities led to changes in wholesale prices, but changes in wholesale quantities resulted from changes in commercial production and in expected inventory levels.[2]

The wholesale price relation depicted an identical

[1]Project 1367 of the Iowa Agricultural and Home Economics Experiment Station.

[2]The wholesale quantity of beef or pork was defined as the quantity of commercial production, less the net change in cold storage holds during the quarter. If commercial production equaled civilian consumption, then the wholesale quantity also would be equivalent. Historically, however, farm slaughter, military purchases and net exports have contributed to a small numerical difference between wholesale quantity and civilian consumption.

price-quantity relationship for both the production and inventory components of the whole quantity variables. Thus, a net increase in inventory was associated with an increase in price. When inventories were liquidated, the decline in inventories depressed the wholesale price. It made no difference as to the source of the commodity flow—whether current production or cold storage holdings—on the effect that a change in the quantity of beef or pork would have on the wholesale price of beef or pork.

Changes in retail prices were visualized as dependent upon changes in wholesale prices and the effects of trend and seasonality. Meat retailing was characterized by price markups that were affected by gradual and recurrent, or seasonal, changes over time.

Finally, primary market prices were related to wholesale prices. Preliminary investigations of empirical price-quantity relationships at the primary marketing level showed that changes in live prices were related to changes in wholesale prices and to changes in quantities of commercial production. Live and wholesale prices were related to changes in wholesale quantities, but changes in live price were related to changes in wholesale price and live quantity. Changes in live quantity and changes in inventory levels together were related by definition to changes in wholesale quantity.[3]

The operation of the livestock-meat economy was described further by a series of single equations showing the effects of changes in selected explanatory variables on the level of cold storage holdings and of market prices. In generalized form the functional relationships were as follows:

Beef inventory—

$$H_{1t}-H_{1t-4} = F_1(H_{1t-1}-H_{1t-5}, Q_{1t}-Q_{1t-4}, P_{3t-1}-P_{3t-5}, W^*_t, W^r_t) \quad (1)$$

Pork inventory—

$$H_{2t}-H_{2t-4} = F_2(H_{2t-1}-H_{2t-5}, Q_{2t}-Q_{2t-4}, P_{4t-1}-P_{4t-5}, W^*_t, W^r_t) \quad (2)$$

Beef cattle price—

$$\frac{P_{1t}}{P_t} = F_3\left(\frac{P_{3t}}{P_t}, \frac{Q_{1t}}{M_t}, \frac{Q_{1t-1}}{M_{t-1}}, W^*_t, W^r_t\right) \quad (3)$$

$$\frac{P_{2t}}{P_t} = F_4\left(\frac{P_{4t}}{P_t}, \frac{Q_{2t}}{M_t}, \frac{Q_{2t-1}}{M_{t-1}}, W^*_t, W^r_t\right) \quad (4)$$

Beef wholesale price—

$$\frac{P_{3t}}{P_t} = F_5\left(\frac{Q_{3t}}{M_t}, \frac{Q_{4t}}{M_t}, \frac{Y_t}{M_tP_t}, W^*_t, W^r_t\right) \quad (5)$$

Pork wholesale price—

$$\frac{P_{4t}}{P_t} = F_6\left(\frac{Q_{3t}}{M_t}, \frac{Q_{4t}}{M_t}, \frac{Y_t}{M_tP_t}, W^*_t, W^r_t\right) \quad (6)$$

[3]Formulation of prices at the primary markets involves the activities of many different agencies and numerous pricing practices. Meat packing businesses, for example, would take into account the expected marginal cost and marginal revenue at the various levels of operation (1).

Beef retail price—

$$\frac{P_{5t}}{P_t} = F_7\left(\frac{P_{3t}}{P_t}, \frac{V_t}{P_t}, \frac{Y_t}{M_tP_t}, W^*_t, W^r_t\right) \quad (7)$$

Pork retail price—

$$\frac{P_{6t}}{P_t} = F_8\left(\frac{P_{4t}}{P_t}, \frac{V_t}{P_t}, \frac{Y_t}{M_tP_t}, W^*_t, W^r_t\right) \quad (8)$$

H_{1t} is the beef quantity, in millions of pounds, in cold storage holdings in the United States at the end of the t^{th} quarter (11).

H_{2t} is the pork quantity, in millions of pounds, in cold storage holdings in the United States at the end of the t^{th} quarter (11).

M_t is the total population of the United States, corrected for underenumeration, in millions of persons, including the Armed Forces, during the t^{th} quarter (14).

N_t is the total domestic civilian population of the United States, corrected for underenumeration, in millions of persons, during the t^{th} quarter (14).

P_t is the average Consumers' Price Index, 1947-49 = 100, during the t^{th} quarter (13).

P_{1t} is the average primary market price, in cents per pound liveweight, of U.S. Choice grade cattle at 23 major public stockyards in the United States during the t^{th} quarter (8, 12).

P_{2t} is the average primary market price, in cents per pound liveweight, of 200 to 220 pound barrows and gilts at Chicago during the t^{th} quarter (9, 12).

P_{3t} is the average wholesale price, in cents per pound carcass weight, of U.S. Choice grade beef at the New York, Chicago, Los Angeles, San Francisco and Seattle dressed meat markets during the t^{th} quarter (8, 12).

P_{4t} is the average wholesale value, in cents per pound carcass weight, of pork in Chicago computed from Livestock Market News and National Provisioner price quotations during the t^{th} quarter (9, 11).

P_{5t} is the average retail price, in cents per pound carcass weight, of U.S. Choice grade beef in the United States during the t^{th} quarter (8, 11).

P_{6t} is the average retail price, in cents per pound carcass weight, of pork in the United States during the t^{th} quarter (9, 11).

P_{7t} is the average retail price, in cents per pound retail weight, of fryers in the United States during the t^{th} quarter (10, 11).

Q_{1t} is the total commercial production of beef, in millions of pounds carcass weight, in the United States during the t^{th} quarter (11).

Q_{2t} is the total commercial production of pork, in millions of pounds carcass weight, in the United States during the t^{th} quarter (11).

Q_{3t} is the total wholesale quantity of beef, in millions of pounds carcass weight, in the United States; i.e., $Q_{3t} - (H_{1t} - H_{t-1})$, during the t^{th} quarter.

Q_{4t} is the total wholesale quantity of pork, in millions of pounds carcass weight, in the United States; i.e., $Q_{4t} = Q_{2t} - (H_{2t} - H_{2t-1})$, during the t^{th} quarter.

Q'_{5t} is the per capita civilian consumption of beef, in pounds carcass weight, in the United States during the t^{th} quarter (11).

Q'_{6t} is the per capita civilian consumption of pork, in pounds carcass weight, in the United States during the t^{th} quarter (11).

V_t is the index of the ratio of total payroll to the total sales of food stores, 1947-49 = 100, for the United States during the t^{th} quarter (12).

W^*_t is the linear trend term denoting successive quarters of a series where t=1, 2, . . . , 32, starting with the first quarter, 1949.

W^r_t is the term denoting the average recurrent seasonal effects on the levels of cold storage holdings or prices, where t=1, 5, . . . , 29 for r=1, which denotes the first quarter, t=2, 6, . . . , 30 for r=2, which denotes the second quarter, t=3, 7, . . . , 31 for r=3, which denotes the third quarter, and t=4, 8, . . . , 32 for r=4, which denotes the fourth quarter. The W_t value is 1 for the r^{th} quarter and 0 for all other quarters.

Y_t is the total disposable personal income at seasonally adjusted annual rates for the United States during the t^{th} quarter (12).

$\overline{Y}_t$ is the 4-quarter moving average of Y_t, where the values for the current and the preceding three quarters were included in the moving average estimate.

Stochastic, rather than functional, relationships were needed to forecast quarterly price changes. Only the most important of the many factors affecting the dependent variable in each of the functional relationships were known. The effects of other factors were unknown but were represented by the error term in the stochastic expressions of each of the functional relationships. Hence, stochastically, the wholesale price relations, equations 5 and 6, for example, were denoted by,

$$P'_{3t} = a_5 + b_{51}Q'_{3t} + b_{52}Q'_{4t} + b_{53}Y'_t + b_{54}W^*_t + b_{55}W^1_t + b_{56}W^2_t + b_{57}W^3_t + b_{58}W^4_t + u_{5t} \quad (9)$$

$$P'_{4t} = a_6 + b_{61}Q'_{3t} + b_{62}Q'_{4t} + b_{63}Y'_t + b_{64}W^*_t + b_{65}W^1_t + b_{66}W^2_t + b_{67}W^3_t + b_{68}W^4_t + u_{6t}, \quad (10)$$

where the deflated prices and quantities were shown by the superscript (′) and where each of the quarterly effects were shown as separate variables. Thus, the deflated wholesale prices P'_3 and P'_4 were equal to the sums of the estimated relationships times the values of the respective variable—quantity, income or time variables—plus the unexplained error terms u_5 and u_6. Moreover, if certain statistical conditions were fulfilled, the behavior of the unexplained error term could be described on the average over repeated samples. Therefore, the wholesale prices could be estimated, subject to the variability of u_5 or u_6. The estimated price would be equivalent to the actual price less the respective error term.

An arithmetic, rather than a logarithmic, form was used (3, p. 37). Hence, the estimated wholesale price relationships denote the b_{ij} cents change in P'_{it} (i=2, 2; j=1, ..., 8), associated with a 1-pound, a 1-dollar, or a 1-quarter change in an explanatory variable. An arithmetic form for the market relationships was selected because it was believed to represent adequately the likely behavior patterns of marketing firms at each of the three levels in the livestock marketing system with respect to changes in the major price determinants.

Two criteria were used to formulate the stochastic inventory and price relationships: (1) the occurrence, or direction, of dependence among the variables specified in the relationships and (2) the degree of correlation between the error term and the explanatory variables, or the error term in another equation used to estimate an explanatory variable. Each of the explanatory variables was predetermined. Their values were fixed with respect to the estimation of the price variable. Hence, it was necessary to assume that the wholesale prices were established with reference to known values of each of the explanatory variables. The wholesale quantities of beef and of pork and the level of disposable personal income, if estimated, were presumed estimated with certainty, or without bias (3, p. 64). Actually, the errors of estimation, with respect to wholesale quantities and income, were present, though probably of relatively small magnitude. Even though beef cattle and hog producers reacted to changes in live prices during the quarter, and live prices were related to wholesale prices, wholesale quantities were estimated with reference to the probable levels of production, prices and inventories. Hence, a set of unilateral relationships probably did exist between quarterly wholesale quantities and the quarterly wholesale prices.

Generally a high degree of correlation occurred among the quarterly values of different classes of livestock production and meat inventories because of the intertemporal pattern of livestock production and meat consumption in the United States. The use of a set of highly intercorrelated variables explaining changes in market prices presented difficulties in the estimation of the market relationships. Current values of commercial production and of cold storage holdings, for example, could not be used in the same equation. Therefore, the selection of variables involved some consideration of their intercorrelation.

The second criterion involved some notion of the probable behavior of the unexplained error term based on available knowledge regarding the explanatory factors that were not included explicitly. The statistical assumption of a normally and independently distributed error term underlying the use of confidence statements based on the least squares method of estimation would require error terms that were uncorrelated with each other or with the explanatory variables.

Given the estimates of commercial production, wholesale quantity, farm slaughter, military disappearance and net exports, the estimation of market prices was prescribed by two alternative models of market performance. First, the wholesale market was conceived as the critical level in price determination. Wholesale prices were established with reference to the average per capita wholesale quantities of beef and of pork, the average per capita disposable personal income and the pattern of tastes. Quarter-to-quarter changes in wholesale prices, associated with quarterly changes in the explanatory variables, were presumed followed immediately by quarter-to-quarter changes in live and retail prices.

Hence, the average value of the attempted markup at the retail level and at the wholesale level established the average retail and average live prices, given the average wholesale price.

The second approach visualized a less sophisticated role for the wholesale markets in price determination (4). Wholesale price changes merely followed retail price changes. Retail prices were established with reference to the per capita civilian consumption of beef and of pork. Live prices again were determined by the level of wholesale prices and the wholesale markup.

Estimation Procedures

The statistical series needed to estimate the market relationships for purposes of forecasting quarterly changes in beef cattle and hog prices were prescribed in the functional description of the livestock and meat markets. Many of the series, however, were available on a quarterly basis only since the first quarter of 1949. At the time the study was initiated, data were available for the 32-quarter period, 1949-56. Subsequently, additional statistical series became available and were used to test the accuracy of the price forecast based on the average 1949-56 market price relationships.

Several price series were available for each of the two commodities—beef cattle and hogs—at each of the three major market levels. Live prices, for example, would or would not include the value of the items which were sold in the form of by-products. The average wholesale price also would or would not include the value of the by-products. Some retail price series would not include inedible by-products, but they would include some minor cuts of meat which might be classified as by-products.

The three beef price series and the two beef margin series used in this study were related to each other as follows: First, retail and wholesale prices were described in cents per pound carcass weight based on average yield of retail cuts of 80 percent of carcass weight, where (1) retail value denotes the average of prices of individual cuts of U. S. Choice grade beef collected nationally by the United States Bureau of Labor Statistics, (2) wholesale value denotes the average of wholesale prices of U. S. Choice grade beef at five major dressed meat markets in the United States and (3) retailing margin, or the retail-to-wholesale price spread, denotes the difference between the retail value and the wholesale price per pound of U. S. Choice grade beef. Second, the two series of live prices were described in terms of value in cents per pound liveweight based on an average carcass yield of 59 percent of liveweight, where (1) live price denotes the average of prices of U. S. Choice grade cattle at 24 major public stockyards in the United States, (2) by-product credit denotes the average value of beef steer by-products, primarily the value of hide, (3) live value of carcass equivalent denotes the wholesale value in item 2 above multiplied by 0.59 and (4) live-to-wholesale price spread denotes the difference between the live price and live value of carcass equivalent per pound of U. S. Choice grade cattle plus the by-product credit.[4]

The price series for beef were summarized to show their quarterly pattern for the 8 quarters extending beyond the period of analysis (table 1). The wholesaling and retailing margins can be derived from the summary data.

The three pork price series and the two pork margin series represented the major components of the price structure for hogs and pork. The series were related to each other as follows: First, retail and wholesale price series for pork were described in terms of value in cents per pound based on an average yield of 1 pound of the seven major cuts (ham, bacon, loin, picnic, butt, spareribs and bacon square) from about 2.13 pounds of liveweight, where (1) retail value denotes the average of prices of individual cuts of pork collected nationally by the U.S. Bureau of Labor Statistics, (2) wholesale value denotes the average wholesale value per pound of wholesale pork at Chicago computed from Livestock Market News and National Provisioner price quotations of individual cuts and (3) retail-to-wholesale price spread denotes the difference between the retail value and the wholesale value per pound of the seven major cuts. Second, the two live price series were described in terms of value in cents per pound liveweight based on an average yield of 0.4737 pound of the seven wholesale cuts per pound liveweight, where (1) live price denotes the average price per pound of 200-220 pound barrows and gilts at Chicago, (2) by-product credit denotes the average value of hog by-products, largely the value of 0.1502 pound of lard and of 0.0862 pound of other edible pork items per pound of liveweight, (3) live value of seven major cuts denotes the wholesale value of 0.4737 pound of the seven major cuts and (4) live-to-wholesale price spread denotes the difference between the live price and the live value of the seven wholesale

[4]Carcass yields cited in this discussion were used by the United States Department of Agriculture in the construction of the price series reported in "The Marketing and Transportation Situation" (12).

TABLE 1. AVERAGE U. S. CHOICE GRADE BEEF PRICES PER POUND, IN CONSTANT 1947-49 DOLLARS, AT THE RETAIL, WHOLESALE AND PRIMARY MARKET LEVELS, BY QUARTER-YEARS, 1957-58.

Year and quarter-year	Retail value	Wholesale value	Live value		
			Carcass	By-products	Total
	(cents)	(cents)	(cents)	(cents)	(cents)
1957					
January-March	44.6	30.6	15.9	1.6	17.5
April-June	46.5	33.0	17.2	1.8	19.0
July-September	48.2	35.2	18.2	1.9	20.1
October-December	47.9	34.3	18.2	1.7	19.9
1958					
January-March	51.4	37.8	20.3	1.8	22.1
April-June	53.6	38.4	21.1	1.9	23.0
July-September	52.9	36.5	19.4	1.9	21.3
October-December	52.2	36.4	19.9	1.7	21.6
Average, 1949-56	53.2	40.8	21.8	2.4	24.2

TABLE 2. AVERAGE PORK PRICES PER POUND, IN CONSTANT 1947-49, DOLLARS, AT THE RETAIL, WHOLESALE AND PRIMARY MARKET LEVELS, BY QUARTER-YEARS, 1957-58.

Year and quarter-year	Retail value	Wholesale value	Live value		
			Major cuts	By-products	Total
	(cents)	(cents)	(cents)	(cents)	(cents)
1957					
January-March	47.5	36.3	12.7	2.2	14.9
April-June	49.3	37.9	13.7	2.2	15.9
July-September	54.0	41.1	14.8	2.4	17.2
October-December	48.3	35.7	12.8	2.0	14.8
1958					
January-March	51.2	39.7	14.5	2.3	16.8
April-June	53.0	42.0	15.7	2.6	18.3
July-September	54.6	41.4	15.1	2.5	17.6
October-December	50.1	36.7	13.3	2.0	15.3
Average, 1949-56	51.9	40.7	15.3	2.6	17.9

cuts plus the by-product credit.[5]

Similarly, the pork price series were summarized (table 2). Finally, the retailing and wholesaling margins for pork may be obtained from the price data.

All quantity series used in the market price relations pertained to carcass weight on a per capita basis. (See table 3 and table 4 for the quantity series for the 1957-58 period.) During the 32-quarter period, 1949-56, the average estimated yield of beef and pork was, respectively, 55 pounds and 57 pounds per 100 pounds liveweight. Somewhat different concepts were used, however, in relating whoelsale prices and the wholesale quantities to carcass weights. A 1 pound change in wholesale quantity pertained to carcass weights based on average, 1949-56, dressing yields of 55 percent and 57 percent, respectively, while the wholesale beef and pork prices pertained to carcass weights based on average dressing yields of 59 percent and 47 percent, respectively. The former dressing yields were obtained from monthly data on federally inspected slaughter complied by the United States Department of Agriculture (11). These yield percentages were based on the total production of beef and pork and the total liveweight of the cattle and hogs slaughtered. Moreover, the pork yield of 57 percent included edible by-products as well as the seven major cuts. The second set of dressing yields, however, pertains to the U.S. Choice grade carcasses and the seven wholesale pork cuts, respectively.

The total population in the United States, including the Armed Forces, was used to adjust the total commercial production and the total wholesale quantity to obtain per capita quantity series. The total commercial consumption and the total civilian consumption, however, were divided by the total civilian population in the United States. The population data in tables 3 and 4 were not adjusted for underenumeration (of about 1.39 percent).

[5]Percentage yields of the seven wholesale pork cuts were as follows:

Hams, smoked, skinned, 12-14 pounds	11.93
Picnics, 6-8 pounds	6.21
Bacon, 8-12 pounds	10.56
Loins, 8-12 pounds	9.36
Butts, 4-6 pounds	5.06
Spareribs, 3 pounds and down	1.57
Jowl butts (loose)	2.68

TABLE 3. SUPPLY AND DISTRIBUTION OF BEEF IN POUNDS PER CAPITA, BY QUARTER-YEARS, 1957-58.

Year and quarter-year	Commercial production[a] Q'_1	Inventory change[a] H'_1	Net shipments[a] H^*_1	Commercial consumption[b] Q'_3	Farm slaughter[b] Q^*_1	Total consumption[b] Q'_5
1957						
January-March	20.7	-0.4	0.5	20.9	0.6	21.5
April-June	19.8	-0.4	0.2	20.3	0.5	20.8
July-September	20.9	0	0.1	21.1	0.4	21.5
October-December	19.8	0.2	-0.2	20.1	0.6	20.7
1958						
January-March	18.3	-0.1	-0.2	18.9	0.6	19.5
April-June	18.3	0	-0.5	19.0	0.5	19.5
July-September	19.4	0.1	-0.6	20.2	0.8	21.0
October-December	18.2	0.2	1.6	19.7	0.5	20.2

[a]Derived from estimates by months of total production and distribution of pork and from estimates by months of total population in the United States, unadjusted for underenumeration.
[b]Derived from estimates by months of population eating out of civilian food supplies, unadjusted for underenumeration.

TABLE 4. SUPPLY AND DISTRIBUTION OF PORK IN POUNDS PER CAPITA, BY QUARTER-YEARS, 1957-58.

Year and quarter-year	Commercial production[a] Q'_2	Inventory change[a] H'_2	Net shipments[a] H^*_2	Commercial consumption[b] Q'_4	Farm slaughter[b] Q^*_2	Total consumption[b] Q'_6
1957						
January-March	14.9	0.4	0.4	14.3	1.6	15.9
April-June	13.1	-0.5	0.3	13.4	1.2	14.6
July-September	12.5	-0.9	0.3	13.2	0.8	14.0
October-December	15.6	0.3	0.2	15.2	1.8	17.0
1958						
January-March	13.8	0.2	0.2	13.5	1.5	15.0
April-June	13.0	-0.1	0.2	13.1	1.1	14.2
July-September	13.0	-0.5	0.2	13.4	0.6	14.0
October-December	15.2	0.5	0.1	14.7	1.8	16.5

[a]Derived from estimates by months of total production and distribution of pork and from estimates by months of total population in the United States, unadjusted for underenumeration.
[b]Derived from estimates by months of population eating out of civilian food supplies, unadjusted for underenumeration.

Conceptually, the wholesale quantity and the commercial consumption series shown in tables 3 and 4 are different. Wholesale quantity was defined as equivalent to commercial production less the net change in inventory. Consumption from commercial supplies (i.e., commercial consumption), however, also included an adjustment for the net exports and the withdrawals by military agencies, designated as net shipments. Moreover, total domestic civilian consumption from commercial supplies of beef and pork was equivalent to total commercial production, less the change in inventory and the net shipments, and plus the farm slaughter.

A recursive approach was used in both concepts of market performance (3, p. 64). The reaction sequence from wholesale quantity to wholesale price to retail price and live price, or from retail quantity to retail price to wholesale price to live price, involved a relatively short time interval. Current values of each of the variables were involved in the estimation of the price relationships. Estimated values of the explanatory variables, presumably unbiased, were used to compute the live-wholesale and retail-wholesale price relationships. Thus, unbiased estimates were obtained of the market price relationships, assuming the underlying statistical assumptions were fulfilled (3, p. 64-65).

Several different criteria were used to establish the adequancy of the estimated market relationships for predicting quarterly price changes. First, the coefficient of multiple determination, R^2, was used to show the percentage of total variation of a dependent variable that was explained by the explanatory variables. The occurrence of a high degree of intercorrelation among the explanatory variables, or of other forms of spurious correlation, resulted in a relatively large value of the coefficient but a relatively low degree of predictive accuracy.

The standard error of a regression coefficient, s_{b5g}, in equation 9, for example, was used to make an interval estimate of the price relationship, B_{5g}. Thus, probability statements were made regarding the limits of the price relationship with reference to the estimated value. It could be said, for example, that the price relationship, B_{5g}, had a value within the limits, $b_{5g} \pm s_{b5g}$, unless the sample upon which the estimate is based was one of the different kind that occurs about once in three trials. The standard errors of regression are shown in parentheses below the regression estimates in the tabular summaries.

The correlation coefficients used in the computation of the regression coefficients were examined for intercorrelation among the explanatory variables. A simple correlation coefficient of near unity provided information to reject certain variables and to evaluate critically the estimates obtained on the basis of other variables which were included despite the high degree of intercorrelation. The r table was used, therefore, as an additional criterion to evaluate the accuracy of the single equation, recursive approach in forecasting quarterly price changes.

Finally, the standard error of forecast was computed for a wholesale beef price relation and a wholesale pork price relation to show the computed confidence limits of the individual quarterly wholesale price forecast based on the values of the explanatory variables for the first, second and third quarters in 1957—a period extending beyond the 32-quarter period used to compute the prediction equations. A comparison of the R^2 value and the standard error of forecast for each of the prediction equations supplemented the first criterion as a test of predictive performance.[6]

ALTERNATIVE FORECASTING METHODS

The two models of price determination—at the wholesale level and at the retail level—were used to select the variables to forecast changes in beef and pork prices at each of the three market levels. First, however, the estimated inventory relationships were used to obtain the current quantities of beef and pork in the wholesale price relations.

Estimation of End-of-Quarter Cold Storage Holdings

Changes in the levels of cold storage holdings, commercial production and wholesale prices over the same quarter a year ago were related to changes in the current level of cold storage holdings of beef or of pork (see equations 1 and 2). The three explanatory variables —the year-to-year trend in cold storage holdings lagged 1 quarter, the year-to-year trend in commercial production and the year-to-year trend in wholesale price lagged 1 quarter—accounted for 72 percent and 82 percent, respectively, of the variation in the year-to-year trend in cold storage holdings of beef and pork (table 5).

Each of the inventory effects was significant at the 1-percent or 5-percent level. Numerically, an increase of 175 million pounds, or 1 pound per capita, in the level of cold storage holdings of beef at the end of the preceding quarter over the same quarter a year ago was associated, on the average during the 1949-56 period, with an increase of 122 million pounds, or 0.70 pound per capita, in the current end-of-quarter inventory level. The effect of the lagged trend on the current trend in pork cold storage holdings, however, was relatively small. The effect of a change in the current trend of commercial pork production, however, was relatively large. Moreover, the effects of an increasing trend in commercial pork production probably differed from the ef-

[6]Successive values of the residuals from the regression equations were correlated with the same series lagged one quarter for several market price relations. The Durbin-Watson d-test was used to test for mutual independence in the unexplained residuals (3, p. 173).

TABLE 5. ESTIMATED EFFECTS ON LEVELS OF BEEF AND PORK COLD STORAGE HOLDINGS OF A + 1 MILLION POUND CHANGE IN THE LEVEL OF COLD STORAGE HOLDINGS AT THE END OF THE PRECEDING QUARTER, A + 1 MILLION POUND CHANGE IN COMMERCIAL PRODUCTION, AND A + 1 CENT CHANGE IN WHOLESALE PRICE FOR THE PRECEDING QUARTER, BY QUARTER-YEARS, 1949-56.

Cold storage holdings	Lagged cold storage holdings H^*_1 or H^*_2	Commercial production Q_1 or Q_2	Lagged wholesale price P'_3 or P'_4	Constant term 1
	(millions of pounds)			
Beef	0.70**	0.09**	5.87**	-6.10
	(0.11)	(0.03)	(1.63)	
Pork	0.53**	0.30**	5.00*	-13.29
	(0.11)	(0.04)	(2.29)	

*Significant at the 5-percent level.
**Significant at the 1-percent level.

fects of a decreasing trend in commercial pork production—a difference that was not tested statistically. The effects of a 1 cent change in the lagged wholesale price trends were approximately the same, however, for the two prediction equations. Slight refinement of the inventory prediction equations probably would improve the quarterly estimates and thus make the estimates of wholesale quantity highly accurate, given the estimates of commercial production.

Price Determination in Relation to the Wholesale Market

WHOLESALE PRICE RELATIONS

Attainment of equilibrium prices in the dressed meat markets may depend on numerous local conditions. Over longer periods of time—a quarter-year as compared with a week—the quantities of beef and pork in commercial channels and the incomes and tastes of consumers gradually shift the level of the weekly price fluctuations. The analyses covering the 1949-56 period show that over 94 percent of the quarterly variation in wholesale beef or pork prices was attributed to changes in the quantities of beef and of pork and to changes in the incomes and tastes of consumers. Part of the estimated shift in wholesale prices, however, was the result of shifts in the quality composition of total wholesale quantities of beef and pork, particularly with respect to beef supplies.

Estimated effects of changes in the quarterly values of wholesale quantities of beef and pork, and of income and time, are summarized in table 6. Wholesale equation IA includes only the effects of changes in beef and pork quantities and time. Thus, during the 1949-56 period, a change of + 1 pound in per capita wholesale quantity of beef was associated, on the average, with a change of –3.71 cents in the wholesale price of beef and of –1.79 cents in the wholesale price of pork, each in constant 1947-49 dollars. In addition, a + 1 pound change in the per capita quantity of pork at the wholesale level was associated with a –0.63 cent change in beef price and a –4.59 cent change in pork price. The standard errors of the estimated relationships ranged from 0.39 to 0.69. Only the pork quantity effect on beef price was not significant at the 1-percent level.

Wholesale equation II did include an income variable —current disposable personal income in equation IIA and moving average disposable personal income in equation IIB. The income variable, however, was highly correlated with the trend variable. Hence, errors were introduced in the estimation of the wholesale price relationships. Only the estimates of the pork price relationships, however, were significantly different using equation II. Interestingly, each of the coefficients obtained with equation II was larger numerically than the comparable coefficient obtained with equation I. The greater inverse effects of changes in wholesale quantities were offset by the greater seasonal effects on wholesale price.

Wholesale equation IIIA included the current income variable and also a production trend variable. Year-to-year changes in the per capita commercial production of beef and of pork for the preceding quarter were presumed to have a negative effect on wholesale prices. Nevertheless, only the effect of changes in the beef quantity trend on pork price was significant, but the estimated value failed to support the initial hypothesis.

Finally, the moving average income effect was deleted from the two wholesale price series using the inverse form of the estimated income effects on beef and pork consumption obtained in a related study (7). The original estimates of 0.0061 and 0.0170, denoting the change in beef quantity and pork quantity, respectively, associated with a $1 change in the moving average per capita disposable personal income, were used in the inverse form expression of the consumer demand equations. The estimated effects were subsequently adjusted to the whole-

TABLE 6. ESTIMATED EFFECTS ON WHOLESALE PRICE PER POUND CARCASS WEIGHT OF A + 1 POUND CHANGE IN PER CAPITA WHOLESALE QUANTITY, A + 1 DOLLAR CHANGE IN DISPOSABLE PERSONAL INCOME AND + 1 QUARTER CHANGE IN TIME, SELECTED EQUATIONS, BY QUARTER-YEARS, 1949-56.

Equation	Wholesale quantity		Disposable income	Linear trend	Quarterly effects				Constant term
	Beef Q'_3	Pork Q'_4	Y'	W^*	First W^1	Second W^2	Third W^3	Fourth W^4	1
Beef, IA	–3.71**	–0.63		0.37**	–1.01	–1.76	2.24**	0.53	106.95
	(0.39)	(0.43)		(0.10)	(1.18)	a	(0.93)	(1.43)	
Beef, IIA	–3.73**	–0.68	0.003[b]	0.35*	–0.99	–1.82	2.20**	0.61	103.87
	(0.42)	(0.52)	(0.018)	(0.15)	(1.27)	a	(0.95)	(1.65)	
Beef, IIB	–3.75**	–0.73	0.011[c]	0.30	–0.95	–1.87	2.13**	0.69	94.78
	(0.40)	(0.48)	(0.025)	(0.19)	(1.23)	a	(0.94)	(1.56)	
Beef, IIIA	–3.43**	–0.12	0.006[b]	0.27	–1.18	–1.19	2.65**	–0.27	88.41
	(0.51)	(0.70)	(0.019)	(0.17)	(1.45)	a	(0.98)	(2.07)	
Beef, IVB	–3.87**	–1.07*	0.050[d]	0.05	–0.76	–2.22	1.74**	1.24	121.28
	(0.41)	(0.45)		(0.10)	(1.22)	a	(0.97)	(1.50)	
Pork, IA	–1.79**	–4.59**		0.06	1.59**	–4.18	–3.17	5.76**	136.64
	(0.63)	(0.69)		(0.16)	(1.91)	a	(1.51)	(2.33)	
Pork, IIA	–2.28**	–5.62**	0.069*[b]	–0.33	2.03**	–5.35	–4.09	7.41**	72.65
	(0.69)	(0.85)	(0.031)	(0.24)	(2.08)		(1.57)	(2.72)	
Pork, IIB	–2.22**	–5.75**	0.134**[c]	–0.81**	2.26**	–5.40	4.52	7.66**	–7.08
	(0.60)	(0.72)	(0.037)	(0.28)	(1.84)	a	(1.41)	(2.33)	
Pork, IIIA	–2.79**	–5.69**	0.062*[b]	–0.20	1.86**	–5.46	–3.72	7.32**	89.40
	(0.80)	(1.08)	(0.030)	(0.26)	(2.25)	a	(1.53)	(3.23)	
Pork, IVB	–1.37**	–4.34**	0.133[d]	–0.98**	1.10**	–3.48	–2.06	4.44**	143.47
	(0.48)	(0.53)		(0.12)	(1.44)	a	(1.15)	(1.77)	

[a]Quarterly effects were transformed from a second quarter base in the original computations to an average 1949-56 base. Hence, the standard error of estimate was available only for the three quarters excluding the second quarter. Moreover, the standard error pertains to the original value of the regression coefficient, which may be obtained from the values shown.
[b]Current average quarterly value of disposable personal income.
[c]Moving average quarterly value of disposable personal income.
[d]Based on estimated consumer demand relationships.
*Significant at the 5-percent level.
**Significant at the 1-percent level.

sale-retail price spreads.[7] Again, the estimates of the price-quantity relationships differed slightly from the estimates obtained in equation I. The income effect on wholesale price, it was assumed, resulted only in a shift in price because of the fixed wholesale quantity. Over longer time periods, the income effect would affect the wholesale quantities also, but in the present model of the marketing system the wholesale quantity variable was presumed estimated with certainty and wholesale prices then adjusted accordingly.

Exclusion of the income variable in the wholesale price relations resulted in less biased and probably more reliable estimates of the wholesale price relationships for periods of relative income stability. The current income effect probably was negligible during the 1949-56 period —an hypothesis that could not be tested satisfactorily because of the high degree of intercorrelation. During the subsequent 2 years, however, the income effects may have become more pronounced. But the available forecasting procedures were somewhat inadequate to estimate the short-term income effects during the recent period of sharply changing consumer expectations (5).

MARKETING MARGIN RELATIONS

Retail price and live price changes were related to changes in wholesale prices and time. In addition, quarter-to-quarter changes in commercial production were included in one set of live price relations. Thus, the wholesale market was conceived as the most sensitive of the three market levels in price determination. Prices, presumably, were established with respect to both supply and demand conditions. Moreover, retailers followed wholesale price changes, if not daily, at least over 3-month periods.

The retailing margin, or the wholesale-to-retail price spread, was comprised of three different components: a fixed componet, a variable componet directly proportional to the wholesale price and a variable component related to time and comprised of two subcomponents—a gradual linear change in the price spread and a recurrent quarterly change fluctuating about the linear trend. The retailing margins, S'_{5t} and S'_{6t}, can be derived from the retail price relations shown in table 7 (where $P'_{5t} - P'_{3t} = S'_{5t}$ and $P'_{6t} - P'_{4t} = S'_{6t}$).

Retail price equation IA was based on reported wholesale prices and a set of dummy variables to denote a linear quarterly trend and recurrent quarterly effects, which, altogether, accounted for 98 percent of the variation in retail prices in both price relations.[8] A 1 cent change in wholesale beef price was associated with about a 1 cent change in retail beef price, but a 1 cent change in wholesale pork price was associated with a 0.93 cent change in retail pork price. Thus the retailing margin for beef was practically fixed during the period of analysis at a level of 11.64 cents in constant 1947-49 dollars. None of the other effects over time were significant with respect to the wholesale-retail price spread for beef. In comparison, the pork retailing margin varied inversely in relation to the wholesale pork price. Moreover, the positive fourth quarter effect for pork was significant at the 1-percent level. The fluctuations in the wholesale-retail price spread for pork during the 1949-56 period were relatively small, however, in relation to the fixed component of 13.05 cents.

Retail price equation IB was based on predicted wholesale prices (using wholesale equation I). The dummy variables denoting the quarterly effects were omitted except for the fourth quarter effect on retail pork price. Only the estimated pork price relationships seemed to differ in the two equations. The fixed component was larger and the variable wholesale price component was smaller in the second pork equation. In addition, the fourth quarter effect was not significant. Hence, the wholesale-to-retail price spread for pork was affected more by short-term changes in predicted wholesale prices than reported wholesale prices. In either event, the variability in wholesale pork prices was reduced at the retail level by compensating, or negative, changes in the retailing margin.

Price changes at the primary market level were depicted as a function of wholesale price changes and time in live price equation I. In live price equation II, the quarter-to-quarter change in per capita commercial production also was included (table 8). Each of the price equations accounted for 97 percent or more of the variation in live prices. The test for autocorrelation of the unexplained pork residual term, however, was significant. Hence, a lag effect on live price was evident but not included explicitly in the live pork price equations.

Since live prices were on a liveweight basis and wholesale prices on a carcass weight basis, the derivation of the live-to-wholesale price spreads involved an adjustment of the coefficients in table 8. (The wholesale

[7]The adjustments were performed on the deflated wholesale price series using the expressions, $P'_{3t} - (0.050)(Y'_t - 1{,}249) = P''_{3t}$, and $P'_{4t} - (0.133)(Y'_t - 1{,}249) = P''_{4t}$, to obtain respectively, the adjusted beef prices, P''_{3t}, and the adjusted pork prices, P''_{4t}.

[8]The linear trend included the composite effects of changes in marketing, costs, consumer incomes and tastes on the price spread or marketing margin.

TABLE 7. ESTIMATED EFFECTS ON RETAIL PRICE PER POUND CARCASS WEIGHT OF A +1 CENT CHANGE IN WHOLESALE PRICE AND A +1 QUARTER CHANGE IN TIME, BY QUARTER-YEARS, 1949-56.

Retail price	Wholesale price P'_3, P'_4	Linear trend W^*	Quarterly effects				Constant term 1
			First W'	Second W^2	Third W^3	Fourth W^4	
				(cents)			
Beef, IA	1.01**	0.03	0.10	0.12	-0.48	0.26	11.64
	(0.04)	(0.03)	(0.55)	a	(0.56)	(0.56)	
Beef, IB	1.03**	0.04					10.67
	(0.07)	(0.05)					
Pork, IA	0.93**	0.03	-0.44	-0.66	-0.07	1.17**	13.05
	(0.04)	(0.02)	(0.40)	a	(0.39)	(0.41)	
Pork, IB	0.78**	-0.01				-0.10	20.42
	(0.10)	(0.05)				(0.99)	

[a]Less than 0.005.
**Significant at the 1-percent level.

TABLE 8. ESTIMATED EFFECTS ON LIVE PRICE PER POUND LIVEWEIGHT OF A +1 CENT CHANGE IN WHOLESALE PRICE, A +1 POUND CHANGE IN PER CAPITA COMMERCIAL PRODUCTION, AND A +1 QUARTER CHANGE IN TIME, BY QUARTER-YEARS, 1949-56.

Live price	Wholesale price P'_3 , P'_4	Production: Beef Q'_1	Production: Pork Q'_2	Linear trend W^a	Quarterly effects: First W^1	Quarterly effects: Second W^2	Quarterly effects: Third W^3	Quarterly effects: Fourth W^4	Constant term I
					(cents)				
Beef, IA	0.66** (0.02)	.....	.....	-0.10 (0.07)	0.39 (0.57)	0.12 a	-0.50 (0.56)	-0.01 (0.55)	-2.24
Beef, IIA	0.66** (0.02)	-0.29* (0.13)	-0.17 (0.13)	-0.02 (0.01)	.....	.....	0.16 (0.26)	.....	-2.28
Beef, IIIB	0.69** (0.03)	-0.38 (0.29)	.....	.....	.....	.....	-0.22 (0.59)	.....	-3.80
Beef, IIIC	0.60** (0.03)	-0.26 (0.26)	.....	.....	.....	.....	-0.33 (0.52)	.....	-2.67
Pork, IA	0.61** (0.03)	.....	.....	b	0.96** (0.32)	-0.08 b	-0.73 (0.32)	-0.14 (0.34)	-6.88
Pork, IIA	0.62** (0.01)	0.24** (0.05)	-0.06 (0.04)	b	-0.10 (0.08)	.....	.....	0.10 (0.08)	-7.20
Pork, IIIB	0.54** (0.04)	.....	0.38 (0.28)	.....	0.29 (0.57)	.....	.....	.....	-4.05
Pork, IIIC	0.45** (0.04)	.....	0.48 (0.25)	.....	0.35 (0.50)	.....	.....	.....	-3.00

[a]Base quarter in original computations.
[b]Less than 0.005.
*Significant at 5-percent level.
**Significant at 1-percent level.

price coefficient for beef was multiplied by the reciprocal of carcass yield per pound, i.e., 1.69, and the wholesale price coefficient for pork was multiplied by the reciprocal of the yield of the seven wholesale cuts per pound, i.e., 2.13.) Thus, using live price equation IA, a 1 cent change in wholesale beef price on a carcass weight basis was associated with a 0.66 cent change in beef cattle price on a liveweight basis. But a 1 cent change in wholesale beef price on a liveweight basis was associated with a 1.12 cent change in beef cattle price. Similarly, a 1 cent change in wholesale pork price on a liveweight basis was associated with a 1.3 cent, rather than a 0.61 cent, change in hog price on a liveweight basis.

Both the beef and the pork live-to-wholesale price spreads were inversely related to changes in live prices when converted to a live price basis. Thus, by transposition of the variables and their coefficients in table 8,

$$\frac{\Delta S'_{3t}}{\Delta P'_{1t}} = -0.12 \text{ and } \frac{\Delta S'_{4t}}{\Delta P'_{2t}} = -0.23,$$

where, $S'_{3t} = P'_{3t} - P'_{1t}$ and $S'_{4t} = P'_{4t} - P'_{2t}$, and where small changes in the variables are denoted by Greek letter delta (Δ). Only effects of changes in wholesale prices were significant in the live price equations, except for the first-quarter increase in the pork wholesale margin. Hence, the derived margins were comprised of two significant components: a fixed component and a variable price component. The variable component was dependent on the behavior of live prices; the latter were dependent not only upon changes in wholesale prices but also upon changes in inventories. Hence, a more complete expression of the wholesaling margin would include the effects of inventory and price changes on the live-to-wholesale price spread.

Live price equations IA and IIA were based on reported values of wholesale prices. Equations IIIB and IIIC, however, were based on estimated wholesale prices. In addition, the value of the by-products was deducted from the prices of beef cattle and hogs in equation IIIC. Thus, the live price series used in the last equation pertained to the liveweight equivalent of the carcass weight used in the wholesale price series.

The association between reported live prices and adjusted live prices, was described by the form,

$$P'_{1t} = -0.71 + 1.14P'^*_{1t}, \text{ and} \quad (11)$$

$$P'_{2t} = -0.16 + 1.18P'^*_{2t}, \quad (12)$$

where P'^*_{1t} was the adjusted beef cattle price and P'^*_{2t} was the adjusted hog price. The value of by-products comprised, therefore, a fixed component and a variable component, where the variable component was $0.12P'_{1t}$ for beef cattle and $0.15P'_{2t}$ for hogs in terms of the reported prices.

Accurate predictions of the value of by-products would require some consideration of the prospective markets for hides and lard, both domestic and foreign, inasmuch as these items comprise a major part of the total value of by-products. During the 1949-56 period, however, the derived price reaction coefficients quite accurately depicted the relationship between the reported live prices per pound liveweight and the live prices adjusted for the value of by-products.

Price Determination in Relation to the Retail Market

A set of two consumer demand equations showing the effects of changes in retail beef price, retail pork price, retail poultry price, disposable personal income and time was used to derive the inverse form equivalents of the consumer demand relationships (7). The derived regression coefficients showing the effect of a 1 unit change in per capita civilian consumption (including farm slaughter), poultry price, income and time on the retail price of beef and pork (see table 9) may be compared with the coefficients for the wholesale market level. A somewhat different concept of quantity was used, hence the coefficients would not be directly comparable even if the retail-wholesale price relationships were involved in the comparison.

Wholesale prices can be estimated, given the estimated retail prices and the retail-to-wholesale price spreads. Data in table 7 may be adjusted, using wholesale price as the dependent variable, to obtain the needed

TABLE 9. ESTIMATED EFFECTS ON RETAIL PRICE PER POUND CARCASS WEIGHT OF A + 1 POUND CHANGE IN PER CAPITA CIVILIAN CONSUMPTION, A + 1 CENT CHANGE IN POULTRY PRICE, A + 1 DOLLAR CHANGE IN INCOME AND A + 1 QUARTER CHANGE IN TIME, BY QUARTER-YEARS, 1949-56.

Equation	Civilian consumption: Beef Q'_5	Civilian consumption: Pork Q'_6	Poultry price P'_7	Disposable income Y'	Linear trend W^*	Quarterly effect: First W^1	Quarterly effect: Second W^2	Quarterly effect: Third W^3	Quarterly effect: Fourth W^4	Constant term 1
Beef	-4.03	-1.60	0.23	0.052	0.09	-0.90	-3.10	0	4.00	64.35
Pork	-1.36	-5.61	0.25	0.104	-0.83	1.27	-5.54	-7.23	11.50	23.95

price reaction coefficients by quarters. Thus, retail, wholesale and primary market prices can be predicted, given the values of the explanatory variables at the retail or consumer level.

Evaluation of Findings on Vertical Price Relationships

The estimates of the market price relationships may be examined further in terms of price flexibility and price reaction coefficients for each of the three levels in the livestock and meat marketing system. First, a price flexibility coefficient was defined as the estimated percentage change in a market price associated with a given percentage change in a quantity variable, or some other explanatory variable. A price reaction coefficient was defined as the estimated percentage change in a market price associated with a given percentage change in another price variable. A demand elasticity coefficient was defined as the estimated percentage change in a quantity variable associated with a given percentage change in a price or income variable. The derived price elasticities of demand at the wholesale market level, for example, could be obtained from the derived quantity-price relationships,

$$\frac{\partial Q'_{3t}}{\partial P'_{3t}} = \frac{b_{42}}{(b_{31}b_{42} - b_{32}b_{41})}, \text{ and} \qquad (13)$$

$$\frac{\partial Q'_{4t}}{\partial P'_{4t}} = \frac{b_{31}}{(b_{31}b_{42} - b_{32}b_{41})}. \qquad (14)$$

Thus, the own-price elasticity of demand for beef, $E_{q3.p3}$ would be represented by the expression,

$$E_{q3.p3} = \left(\frac{\partial Q'_{3t}}{\partial P'_{3t}}\right)\left(\frac{\overline{P}_3}{\overline{Q}_3}\right). \qquad (15)$$

Similarly, the price elasticity of demand for pork was obtained from the derived quantity-price relationships and the mean values of the price and quantity variables for the 1949-56 period (see table 10, method A).

Price flexibility coefficients for two wholesale price relations, wholesale price equations I and IVB, are included in table 11. Each of the coefficients was computed at the mean 1949-56 values of the price and quantity variables. Thus, at the wholesale level, pork prices were relatively more flexible than beef prices with respect to given changes in beef or pork quantities during the period covered by the analyses.

Price reaction coefficients for retail price equation IA and live price equation IA are shown in table 12. A 1 percent change in wholesale beef price was associated with a 0.78 percent change in retail beef price. A 1 percent change in wholesale pork price was associated with a 0.73 percent change in retail pork price. The live price reaction coefficients were significant, also, but greater than unity. Thus, the level of the live or retail price affected the magnitude of the price reaction coefficient in each price relationship.

Finally, the price reaction coefficients were used to obtain estimates of demand elasticities at each of the three levels in the marketing system (see table 10, method B). For example, the retail demand elasticity coefficient, $E_{q5.p5}$, may be expressed by the formula,

$$E_{q5.p5} = \left(\frac{\partial Q'_{5t}}{\partial P'_{5t}}\right)\left(\frac{\overline{P}'_5}{\overline{Q}_5}\right), \qquad (16)$$

where Q'_{5t} and P'_{5t} denote retail beef quantity and re-

TABLE 10. ESTIMATED AVERAGE PRICE ELASTICITIES OF DEMAND FOR BEEF AND PORK BASED ON TWO METHODS OF ESTIMATION, RETAIL, WHOLESALE AND PRIMARY MARKET LEVELS, 1949-56.

Item	Retail market	Wholesale market: Method A, Wholesale equation IA	Wholesale market: Method A, Wholesale equation IVB	Wholesale market: Method B using retail equation IA	Primary market using Method B and live equation IIIC
		(percent)			
Beef	-0.85	-0.68	-0.67	-0.67	-0.60[a]
Pork	-0.62	-0.62	-0.67	-0.44	-0.37[a]

[a]Fixed levels and pork and beef inventories, excluding the by-product components of beef cattle and hog prices.

TABLE 11. EFFECT ON WHOLESALE PRICE OF BEEF AND PORK PER POUND OF A + 1 PERCENT CHANGE IN WHOLESALE QUANTITY OR DISPOSABLE PERSONAL INCOME, OR A + 1 UNIT CHANGE IN TIME, BY QUARTER-YEARS, 1949-56.

Explanatory variable	Wholesale price, IA: Beef	Wholesale price, IA: Pork	Wholesale price, IVB: Beef	Wholesale price, IVB: Pork
	(percent)			
Beef quantity	-1.59**	-0.77**	-1.65**	-0.58**
Pork quantity	-0.24	-1.72**	-0.40*	-1.63**
Annual trend	-3.64**	0.64	0.12	-2.41**
First quarter	-2.73**	3.91**	-1.86	2.70**
Second quarter	-4.57[a]	-10.26[a]	-5.44[a]	-8.55[a]
Third quarter	5.25**	-- 7.79	4.27**	-5.05
Fourth quarter	1.05	14.14**	3.03	10.90**

[a]Standard errors of estimate for the second-quarter effects were not available because of the computational method.
*Significant at the 5-percent level.
**Significant at the 1-percent level.

TABLE 12. EFFECT ON RETAIL PRICE OF BEEF AND PORK PER POUND OF A + 1 PERCENT CHANGE IN ESTIMATED WHOLESALE BEEF AND WHOLESALE PORK PRICES, BY QUARTER-YEARS, 1949-56.

Explanatory variable	Retail price, IA: Beef	Retail price, IA: Pork	Live price, IA: Beef	Live price, IA: Pork
	(percent)			
Wholesale price	0.78**	0.73**	1.12**	1.39**
Annual trend	0.19	0.15	-0.33	0.00
First quarter	-0.04	-0.43	-0.05	0.99
Second quarter	-0.05	-0.46	-0.12	-0.53
Third quarter	0.13	-0.28	0.27	0.06
Fourth quarter	-0.04	1.17**	-0.10	-0.52

**Significant at the 1-percent level.

tail beef price, respectively. If, however, beef inventories at the retail level are negligible, then retail beef quantity and wholesale beef quantity can be assumed equivalent. Hence, the wholesale demand elasticity coefficient, $E_{q3.p3}$, may be specified by the form,

$$E_{q3.p3} = E_{q5.p5}\left(\frac{\bar{P}'_3}{\bar{P}'_5}\right)\left(\frac{\partial P'_{5t}}{\partial P'_{3t}}\right), \qquad (17)$$

where the partial derivative, $\partial P'_{5t}/\partial P'_{3t}$, is equivalent to the regression coefficient of retail price with respect to wholesale price. Finally, the form,

$$E_{q1.p1} = E_{q3.p3}\left(\frac{\bar{Q}'_3}{\bar{Q}'_1}\right)\left(\frac{\bar{P}'_1}{\bar{P}'_3}\right)\left(\frac{\partial P'_{3t}}{\partial P'_{1t}}\right) + \left(\frac{\partial H'_{1t}}{\partial P'_{1t}}\right)\left(\frac{P'_1}{\bar{Q}_1}\right), \qquad (18)$$

denotes the components of the live demand elasticity coefficient, which is comprised of the retail and wholesale demand elasticities and the inventory demand elasticity. Thus, the live demand elasticities would have an additional source of instability—the effect of changes in inventory levels on live prices. Changes in live prices would be directly proportional to changes in inventory levels. Hence, the reciprocal of the price-inventory relationship would vary directly with changes in inventory levels. Thus, the depressive price effects of sharp changes in commercial production would be reduced.

The wholesale demand elasticity coefficients for beef and pork may be estimated from the data in table 6 using the adjusted values of the wholesale price relationships (see table 10). The live demand elasticity coefficients also can be derived if fixed inventory levels are assumed, thus making $Q'_{3t} = Q'_{1t}$ and $(\partial H_{1t}/Q'_3) \div (\partial P'_{1t}/P'_1) = 0$. Furthermore, the own-price elasticity coefficients of demand for beef and pork, –0.85 and –0.62, may be used to derive price elasticity coefficients at the wholesale and primary market levels. Differences in the two sets of coefficients in table 10 may be the result of errors in the estimation of the demand and price relationships and limitations in the underlying assumptions.

In summary, the findings on price flexibility and demand elasticity coefficients suggest the following conclusions:

1. The estimated own-price flexibility at the wholesale market level, based on the average 1949-56 values of the price and quantity variables, was about –1.6 for beef and about –1.7 for pork.

2. The estimated cross-price flexibility was about –0.3 for beef price and about –0.7 for pork price, at the average 1949-56 values of the two sets of variables.

3. The average annual change in the price of pork due to linear trend probably was about –2.4 percent, or somewhat less, of the average 1949-56 quarterly wholesale price. The trend effect was not significant for beef at the wholesale market level.

4. The composite effects of quarter-to-quarter shifts in the wholesale price relationships were at a peak during the third quarter for beef and during the first and fourth quarters for pork. The quarterly shift in the price of beef, however, probably largely represented the effect of quality changes in the total supply of beef.

5. The price reaction coefficients at retail price with respect to wholesale price on a percentage basis were about 0.8 and 0.7, respectively, for beef and pork. The percentage price reaction coefficients of live price with respect to wholesale price were about 1.1 and 1.4 for beef and pork, respectively.

QUARTERLY PRICE FORECASTS

Beef prices were predicted with a relatively high degree of accuracy for the 1949-56 period, as shown by the small differences between the reported and predicted prices based on wholesale price equation IA (table 13). In comparison, the 1957 and 1958 estimates exceeded the reported prices by as much as 8.6 cents per pound. Beef cattle and beef prices were lower than expected on the basis of the average 1949-56 price-quantity relationships at the primary and wholesale market levels. Retail prices, also were overestimated during most of the 8-quarter period.

Considerable consumer resistance to higher beef prices may have occurred during 1957 and 1958. Consumer incomes were in a period of readjustment, which may have resulted in changes in consumer buying habits. The income elasticity of demand for beef was relatively high—about 0.3, or more—hence the income readjustments may have had an initial impact on the demand for beef. Retail prices lagged behind the changes in wholesale and primary market prices, but the reported and predicted retail prices reached a minimum level for the post-war period during the first quarter, 1957, and thence began an upward climb that brought the two series together by the first quarter, 1958 (table 14). Numerical measures of disposable personal income may need to be supplemented by separate estimates of wages and salaries, indebtedness and liquidity in the form of cash and convertible securities. Financial obligations and income expectations, for example, may have changed substantially during calendar year 1957, though the numerical estimates of income failed to reveal these changes

TABLE 13. REPORTED AND PREDICTED WHOLESALE PRICES OF BEFF AND PORK PER POUND CARCASS WEIGHT, IN 1947-49 DOLLARS, USING WHOLESALE PRICE EQUATION IA, 1949-56.

Year and quarter-year	Beef		Pork	
	Reported	Predicted	Reported	Predicted
		(cents)		
1949, 1	38.1	41.7	45.3	45.7
2	41.3	41.6	44.9	44.5
3	43.9	43.8	48.6	46.6
4	45.0	46.4	39.4	44.7
1950, 1	42.9	44.2	38.6	43.1
2	46.2	44.7	41.6	43.8
3	47.6	46.4	48.8	45.7
4	47.7	45.3	40.4	41.1
1951, 1	50.4	46.9	42.6	41.7
2	51.4	51.4	41.8	38.8
3	51.6	53.6	43.1	41.9
4	51.5	50.6	38.4	39.4
1952, 1	49.9	49.1	36.3	37.2
2	48.7	49.5	39.6	40.1
3	48.3	48.5	43.5	39.8
4	45.7	45.1	37.6	36.2
1953, 1	37.0	39.3	40.8	38.9
2	33.7	34.2	46.5	41.6
3	36.7	36.0	48.8	44.0
4	36.0	33.5	42.6	42.2
1954, 1	34.6	33.9	48.3	47.0
2	35.0	35.8	48.8	50.5
3	35.9	37.2	43.2	50.1
4	37.5	36.7	37.9	42.0
1955, 1	37.2	35.9	36.1	38.5
2	34.7	33.6	38.4	38.7
3	34.6	34.2	37.9	37.1
4	32.3	34.2	31.1	31.3
1956, 1	31.1	30.1	39.8	28.4
2	30.5	30.6	33.9	34.2
3	36.5	35.4	35.1	35.9
4	32.0	35.8	32.8	32.0

TABLE 14. COMPUTED RESIDUAL TERMS FOR SELECTED PREDICTION EQUATIONS SHOWING DEVIATION IN CENTS OF ESTIMATED FROM REPORTED BEEF PRICE, AT THE RETAIL, WHOLESALE AND PRIMARY MARKET LEVELS, BY QUARTER-YEARS, 1957-58.

Year and quarter-year	Wholesale price base										Retail market base price
	Wholesale price differences					Retail price		Live price differences			
	IA	IIA	IIB	IIIA	IVB	IA	IB	IA	IIIB	IIIC	
1957											
January-March	- 1.9	- 1.9	- 2.0	-1.7	- 2.4	2.1	0.3	0.1	-1.4	-1.2	0.6
April-June	- 3.0	- 2.9	- 2.8	-3.9	- 2.1	1.4	-1.5	0.3	-1.4	-1.3	0.4
July-September	- 2.7	- 2.5	- 2.2	-2.7	- 0.8	1.6	-1.7	0.6	-0.7	-0.6	-0.7
October-December	- 5.9	- 5.9	- 5.7	-5.2	- 5.0	0.5	-7.8	0.5	-3.7	-2.9	-2.0
1958											
January-March	- 6.5	- 6.4	- 6.2	-5.8	- 5.1	0.5	-6.2	0.0	-4.6	-3.5	-1.3
April-June	- 6.4	- 6.3	- 5.8	-5.7	- 3.9	2.1	-4.5	0.9	-2.8	-2.1	2.1
July-September	- 8.6	- 8.4	- 7.9	-7.8	- 5.6	3.9	-5.5	1.1	-3.1	2.6	4.1
October-December	-12.1	-12.1	-11.6	-9.5	-10.4	2.4	-8.9	0.9	-8.5	-6.2	0.8

—changes which probably affected the demand for beef and pork.

Observed residual terms for the beef price equation showed a periodicity in their variations (table 13). The peaks or troughs were about 4 years apart—i.e., wholesale prices were overestimated for 2 years, then underestimated for 2 years, and so on. Wholesale prices were overestimated for 1948-49, 1952-53 and 1956-57, and underestimated for the intervening years. Moreover, live prices varied more sharply than wholesale prices.

The autocorrelative properties of the two residual terms were examined further in view of the relatively small values for the d-statistics. The 4-year cycle in the differences between predicted and reported prices for beef was superimposed on at least two other disturbances: (1) the effect of income readjustments in the 1948-49 period associated with the depletion of liquid savings and (2) the effect of price controls during the 1951-53 period. The residual periodicity in the errors of forecast with respect to live and wholesale beef prices could be related to the periodicity in pork production. Pork production was relatively small when beef prices were underestimated and relatively large when beef prices were overestimated. Thus, when pork production increased during the 8 quarters starting with the first quarter of 1954, live and wholesale beef prices were actually lower than predicted.

Live hog and wholesale pork prices were predicted with less accuracy than beef and beef cattle prices, partly as the result of pork storage operations that were not adequately explained by changes in the quantities of beef and pork (see table 13). Furthermore, during the fourth quarter, 1957, an overestimate of the pig crop probably resulted in lower-than-expected levels of inventories and, also, lower wholesale and live prices than expected on the basis of the 1949-56 price-quantity relationships (table 15). (The anticipation of the changes in wholesale prices during 1953 and 1954 also may have been related to inventory operations of meat packers and errors in short-term supply expectations.) Moreover, consumer resistance to pork may have increased sharply during 1957 and 1958, which was not explained entirely by the probable shift in income expectations of consumers. The widespread consumer aversion to certain attributes of pork, as revealed in studies of consumer preferences, may have become more pronounced since the end of calendar year 1956. Thus, during the first quarter, 1958, market prices were overestimated by as much as 9.5 cents.

Observed residual terms for the three pork price equations also varied periodically, particularly with respect to live and wholesale prices. Again, the peaks or troughs were about 4 years apart, but in addition the 4-year cycle was superimposed on a longer cycle of variations. Thus, when predicted beef prices overestimated actual beef prices, predicted pork prices also overestimated actual pork prices. During the 1950-54 period, however, predicted pork prices underestimated actual prices more frequently and more intensely than during the terminal years in the 10-year period.

One of the two components of the periodicity in pork price also may be related to the periodicity in pork production. Similarly, the other component may be related to (1) the income readjustments of 1948-49 and (2) the existence of price controls during most of 1951, 1952 and the first months of 1953. Both beef and pork prices were overestimated during these periods. Hence, price controls probably maintained live and wholesale prices below the levels they would have achieved if the available quantities of beef and pork were to have just cleared the markets without price control. A more precise estimate of price-quantity relationships would account for the change in market relationships because of the governmental policy with respect to the prices of beef and pork.

Finally, the standard errors of forecasts were com-

TABLE 15. COMPUTED RESIDUAL TERMS FOR SELECTED PREDICTION EQUATIONS SHOWING DISCREPANCY IN CENTS OF REPORTED FROM PREDICTED PORK PRICES AT THE RETAIL, WHOLESALE AND PRIMARY MARKET LEVEL, BY QUARTER-YEARS, 1957-58.

Year and quarter-year	Wholesale price base										Retail market base price
	Wholesale price differences					Retail price		Live price differences			
	IA	IIA	IIB	IIIA	IVB	IA	IB	IA	IIIB	IIIC	
1957											
January-March	- 3.9	- 3.9	-5.1	- 2.6	3.4	-1.4	-2.1	-1.5	0.6	0.2	- 0.8
April-June	- 2.3	- 0.6	0.1	0.7	8.5	2.0	-0.3	-0.4	4.0	3.3	1.6
July-September	0.2	3.0	5.3	4.3	13.7	3.2	4.0	-0.5	6.3	5.2	6.5
October-December	- 7.9	- 6.8	-5.3	- 6.3	7.4	1.0	-3.9	-0.1	2.1	1.6	- 0.9
1958											
January-March	- 9.5	- 8.4	-5.9	- 7.9	0.3	0.11	-7.1	-1.7	-0.5	-0.3	0.7
April-June	- 4.1	- 1.1	2.6	0.5	6.8	0.0	-3.0	-0.5	3.5	3.0	6.4
July-September	- 2.3	1.4	5.7	2.2	8.1	1.4	0.5	-0.2	4.0	3.4	11.3
October-December	-11.9	-11.3	-5.5	-14.1	- 2.8	0.3	8.3	0	-1.6	-2.3	2.6

puted for the beef and pork price relations at each of the three market levels (5). It was assumed that the explanatory variables were estimated without error, hence only the dependent variable would be subject to error (because of the exclusion of certain variables).

Standard errors of forecast were obtained for selected quarters in 1957; these did not exceed 2.8 cents. The standard error of forecast for wholesale beef price was 2.8 cents during the second and third quarters of 1957, but for live and retail prices the standard error of forecast was only 1.4 and 1.2 cents, respectively. The standard error of forecast for wholesale pork price was 2.2 cents, while it was 1.9 and 0.9 cents, respectively, for live and retail prices. Thus, the largest standard error of forecast, in relation to the forecast price, was obtained at the primary market level for hogs, where the standard error ranged from 9 to 12 percent of the forecast price during the first three quarters of 1957.

Forecasts of beef and pork prices may be obtained for any quarter, given the quantity of beef and pork at that market level. Thus, if it were known that during the first quarter of 1959 per capita quantities of beef and pork would be the same as during the first quarter, 1958, and the 1949-56 market relationships were to apply also to the 1959 market situation, then only the trend effect on prices would differ in the two forecasts. The effect of random disturbances, however, would result in forecast errors, but the random effect would be estimated within specified degrees of confidence. Hence, the accuracy of the price forecasts for the first quarter, 1959, would depend upon accurate estimates of beef and pork quantities, existence of the 1949-56 market relationships, and the random occurrence of the additional events affecting beef and pork prices.

USES AND LIMITATIONS OF THE FORECASTING METHODS

The estimates of the market price relationships were based on several assumptions or conditions regarding the nature of the explanatory variables included in each of the forecasting equations. The explanatory variables —quantity, income, time or price—were pre-determined with respect to the dependent variable. The error terms, presumably, were independent of the explanatory variables and of the error terms in other equations used to estimate one or more of the explanatory variables. Thus, at least one set of equations for each of the three market levels was quite adequate in forecasting quarterly changes in the market prices of beef cattle and hogs, or beef and pork. Yet, no adequate tests were available to select the best set of forecasting equations, or to establish the reliability of the forecasts for quarterly time periods beyond the 1949-56 period.

The use of the estimated price relationships would require careful preparation of the necessary quantity, income and price series. Total quantity data must be converted to a per capita basis. Hence, estimates of the total population are needed. Moreover, the price and income series must be adjusted to a constant dollar basis. Hence, the Consumers' Price Index is required for each quarter. The explanatory variables actually cannot be estimated without error for any forecast period. Thus, each of the estimated values probably would involve some revision on an ex post basis.

The steps involved in the preparation of the basic data to make the price forecasts are numerous. They would include: (1) collection of quarterly series on commercial beef and pork production; end-of-quarter cold storage holdings of beef and pork; consumption from total commercial supplies; consumption from total civilian supplies; total population—including total domestic and total civilian domestic populations adjusted for underenumeration; retail beef, pork and poultry prices; wholesale beef and pork prices, including the value of beef and pork by-products; beef cattle and hog prices; seasonally adjusted disposable personal income at annual rates; and the Consumers' Price Index; (2) derivation of the adjusted price, quantity and income series; (3) computation of predicted prices, first at the wholesale or retail levels, then at the remaining two market levels; and (4) evaluation of the predicted prices and the differences between reported and predicted prices using one or more of the forecasting equations at each of the three market levels.

Improved price forecasting preocedures would result in several obvious benefits. First, accurate industry-wide price forecasts could reduce uncertainties in decision-making at both the production and marketing levels in the meat-livestock economy. Livestock producers could observe the expected results of changes in the quarterly rates of livestock marketings on beef cattle and hog prices and, consequently, make profitable changes in production and marketing plans. Forecasts of changes in the average level of beef and pork prices at the wholesale and retail levels could assist processors in achieving economies through production scheduling and inventory control. Furthermore, forecasts of the pattern of price changes among the three market levels could be informative to the citizen and the public servant in showing the industry-wide effects of changes in one or more of the major price determinants.

The forecasting procedures show quite simply the aggregative behavior of the livestock and dressed meat markets during the 10-year period following World War II. Despite the numerous steps involved in the preparation of the basic series and despite the pitfalls inherent in the use of historical relationships to forecast the course of future events, the relative simplicity of the procedures and the accuracy of the results attest to their potential usefulness. The average change in wholesale pork prices during any quarter in 1959, for example, may be forecast quite accurately, given the average quarterly levels of beef and pork production, end-of-quarter cold storage holdings and disposable personal income. Thus, given a 15-percent increase in per capita commercial pork production for the fourth quarter, 1958, over the fourth quarter, 1959, and no change in per capita beef production, but a 2-percent increase in per capita income, the live price of hogs probably would decrease about 6.5 cents per pound, based on the prediction equations. The predicted fourth quarter, 1958, price was 20.1 cents per pound liveweight.[9]

The predicted live price was obtained in two steps.

[9]Confidence limits on the predicted values could be computed following the procedure cited by Fox (5).

First, the change in the predicted wholesale price was computed using wholesale price equation IVB. The estimated fourth quarter, 1958, wholesale price was obtained from the data in table 2 and table 15: $P_{4t} - u_{4t} = P_{4t}$, or $36.7 - (-2.7) = 39.4$ cents in constant 1947-49 dollars. The change in price from the fourth quarter, 1958, to the fourth quarter, 1959, was derived using the data in table 6: $P_{4t} = -1.37(0) -4.34(2.25) + 0.133(30) -0.98(4) = -9.59$. Thus, the predicted wholesale price for the fourth quarter, 1959, was 29.8 cents per pound in constant dollars, given a 15-percent increase in the per capita wholesale quantity of pork. In other words, the slaughter of an additional 3 million head of hogs, given a total population of 175 million and an average pork yield of 133 pounds per hog, would be equivalent to an additional 2.25 pounds of pork per capita. If cold storage holdings during the fourth quarter were assumed to remain at the 1958 levels, the change in commercial production would be identical to the change in wholesale quantity. Furthermore, the 2-percent increase in per capita disposable income would be equivalent to about $30 in constant 1947-49 dollars. Since the change occurred over a 4-quarter period, only the trend effect would be relevant in accounting for the shift in tastes.

Live price equation IIIB was used to forecast the effect of the change in the estimated wholesale price on the average live price of 200-220 pound barrows and gilts at Chicago (see table 8). The estimated live price for the fourth quarter, 1958, was 16.9 cents; i.e., $P_{2t} - u_{2t} = P_{2t}$, or $15.3 - (-1.6) = 16.9$ cents in constant 1947-49 dollars. Therefore, the predicted fourth quarter, 1959, live price is 11.7 cents per pound based on a predicted price change of −5.2 cents; i.e., $0.54(-9.6) + 0.38(0) = -5.2$ cents in constant dollars. Moreover, if a Consumers' Price Index of 125 were assumed for the fourth quarter, 1959, then the predicted live price would equal 14.6 cents per pound for 200- to 220-pound barrows and gilts at Chicago. Thus, the effects of the given per capita changes in commercial production and consumer income were converted into a predicted change in the live price of hogs.

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